California Regional Water Quality Control Board

San Francisco Bay Region

Total Maximum Daily Load for Pathogens in the Sonoma Creek Watershed

Project Report
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Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

Sonoma Creek and its tributaries are listed on the Federal Clean Water Act, Section 303(d) list as impaired by pathogens. The Clean Water Act Section 303(d) requires states to establish Total Maximum Daily Loads (TMDLs) for pollutants causing water quality impairments to ensure that impaired waterbodies attain their beneficial uses. The goal of this TMDL is minimize the risk of humans contacting water-borne diseases by assessing pathogen sources and developing and implementing a plan to reduce pathogen loading. Sonoma Creek is also listed as impaired by sediment and nutrients. Actions to reduce multi-pollutants are encouraged in this pathogen TMDL and will be recognized in future TMDLs.

<u>Problem Definition</u>
Elevated levels of fecal bacteria have been observed in Sonoma Creek since the 1970s. These bacteria indicate the presence of fecal contamination and attendant health risk to recreational users of the river from water-borne pathogens. Recent bacterial water quality studies provide a consistent picture of widespread, but moderate and somewhat localized pathogen impairment. Water quality objectives are exceeded at a number of locations in the watershed at all times of year. The most severe and consistent exceedances were observed on Sonoma Creek downstream of the community of Kenwood, with additional exceedances further downstream on Sonoma Creek, and in the Nathanson/Schell Creek watershed.

<u>Numeric Targets</u>
The numeric targets (desired future conditions for the Sonoma Creek watershed) proposed for this TMDL are based on U.S. EPA’s recommended bacterial criteria for recreational waters as cited in the San Francisco Bay Regional Water Quality Control Board’s (Water Board’s) Basin Plan:

- Geometric mean E. coli density of 126 CFU/100 mL;

- Ninetieth percentile E. coli density of 406 CFU/100 mL; and

- Zero discharge of untreated human waste to Sonoma Creek and its tributaries or to groundwater with direct through flow to these surface waters.

The third target is consistent with the Basin Plan’s region-wide prohibition against the discharge of raw sewage.

Source Assessment

Data collected for this TMDL indicate that the following sources contribute significant, controllable pathogen loads in the watershed:

- Faulty septic systems
- Faulty sanitary sewer systems
- Municipal runoff
- Cattle grazing
- Dairies

Monitoring records indicate that discharge from the single publicly owned municipal wastewater treatment plant in the watershed does not contribute significant pathogen loads. Sampling data indicate that wildlife do not constitute a significant pathogen problem.

TMDLs

This report proposes density-based fecal coliform concentrations (number of organisms per unit volume) as Total Maximum Daily Loads for Sonoma Creek and its tributaries. These TMDLs, applicable year-round, are listed in the following table.

Total Maximum Daily Loads for Sonoma Creek and its Tributaries	
Indicator	**TMDL (CFU/100 mL)[a]**
E. coli	Geometric mean < 126 90^{th} percentile < 406
[a]Based on a minimum of five samples collected within a 30-day period.	

Load Allocations

The table below presents the density-based pathogen load allocations proposed for each pathogen source category in the Sonoma Creek watershed. These allocations are not additive, and will apply year-round to the different source categories of pollution in the watershed.

Density-Based Pollutant Load Allocations for Different Pollution Source Categories		
Categorical Pollutant Source	**E. coli Density, CFU/100 mL**	
	Geometric Mean	90^{th} Percentile
Septic Systems	0	0
Faulty Sanitary Sewer Systems	0	0
Municipal Runoff	<126	<406
Cattle Grazing	<126	<406
Dairies	<126	<406
Wildlife	<126	<406

The proposed wasteload allocation for the Sonoma Valley County Sanitation District facility, the only municipal wastewater discharger in the watershed, is a median total coliform density of 23 CFU/100 mL, as specified in the facility's NPDES permit.

Linkage Analysis

An essential component of developing a TMDL is to establish a relationship (linkage) between pollutant loadings from various sources and the numeric targets chosen to measure the attainment of beneficial uses. For this TMDL, the proposed load allocations protect the beneficial uses (the linkage is established) because:

- Fecal waste from warm-blooded animals can contain pathogens;
- Fecal coliform bacteria are present fecal waste from warm-blooded animals and are routinely used as a monitoring surrogate;
- The proposed density-based load allocations are the same as, or more stringent than proposed numeric water quality targets;
- The proposed numeric targets are the same as current U.S. EPA recommended bacterial water quality criteria for recreational waters; and
- The U.S. EPA recommended criteria are conservatively based on epidemiological studies (U.S. EPA, 2002) and are protective of beneficial uses.

Implementation Plan

The implementation plan presented in this report provides a general description of proposed actions necessary to achieve water quality objectives. Actions are proposed for each potential controllable pathogen source category identified in the source assessment: septic systems, sanitary sewer system failure, municipal runoff, and grazing lands. Proposed actions generally involve identification of sources, implementation of actions to reduce these sources, and reporting of progress in source reduction activities. The Water Board and other involved stakeholders will implement existing and developing programs aimed at reducing pathogen sources. These programs will be consistent with the State Water Resource Control Board's *Policy for Implementation and Enforcement of the Nonpoint Source Control Program, May, 2004*

A more detailed implementation plan will be presented in the Basin Plan amendment and accompanying staff report for this TMDL. These documents will include a time schedule for actions, and a description of the compliance monitoring and surveillance to be undertaken to ensure successful implementation. Water Board staff will make an effort to discuss source control actions with all interested stakeholders and seek their input in regard to cost and feasibility.

If after five years the Water Board determines that load and density reductions are being achieved as management measures are implemented, then the recommended appropriate course of action would be to continue management measure implementation and compliance oversight. If it is determined that all proposed control measures have been implemented, yet the TMDL is not achieved, further investigations will be made to determine whether: 1) the control measures are not effective; 2) the high levels of indicator bacteria are due to uncontrollable sources; or, 3) the TMDL is unattainable.

1. INTRODUCTION

The federal Clean Water Act requires states to identify impaired waters and the pollutants causing impairments. This list of water bodies is often referred to as the "303(d) list" (referencing the requirement in section 303(d) of the Clean Water Act). The Clean Water Act also requires states to establish Total Maximum Daily Loads (TMDLs) for the listed pollutants causing the impairments. TMDLs are essentially cleanup or restoration plans for a waterbody that target the specific pollutants causing the impairment of the listed water body. Essential components of TMDLs include: numeric target(s) that define the desired condition of the waterbody; the maximum amount of pollutant(s) or stressor(s) the waterbody can tolerate while meeting these targets; identification of the sources of the pollutant(s) reaching the waterbody; and allocations of pollutant loads or load reduction responsibility to these sources. TMDLs must also include implementation plans describing necessary pollution prevention, control, and restoration actions to restore the water body and/or remove the impairment.

The California Regional Water Quality Control Board, San Francisco Bay Region (Water Board) is responsible for developing TMDLs in the San Francisco Bay region. A phased approach is typically employed for TMDL development. Early phases involve identifying key issues concerning the cause of the impairment and the information needed to understand how to resolve the impairment, meeting with stakeholders, and conducting studies and analyses. This project report presents the results this work.

This report describes the water quality problem causing the impairment, sources of the pollutant reaching the impaired water body, and potential actions needed to restore or cleanup the water body. Our primary purpose is to provide an opportunity for stakeholders to comment on the scientific basis of the TMDL and on the preliminary implementation strategy. Stakeholder participation is essential for a successful TMDL, helping to ensure that the TMDL provides a "real solution to a real problem."

After obtaining stakeholder input, Water Board staff will develop a proposed amendment to the Water Board's Water Quality Control Plan (Basin Plan) and an accompanying staff report. The Basin Plan amendment is the means by which the Water Board formally establishes the TMDL. The amendment and staff report will contain a detailed implementation plan, identify responsible parties and schedules for actions, and specify monitoring to track the actions and attainment of water quality standards. Additional studies may be prescribed to confirm key assumptions made while developing the TMDL, resolve any uncertainties remaining when the TMDL is adopted, and establish a process for revising the TMDL, as necessary, in the future.

The Water Board will hold two public hearings (located in Oakland) for this TMDL. The first, a testimony hearing, is anticipated in spring 2006. This hearing will provide an opportunity for interested parties to comment on the proposed Basin Plan amendment and associated staff report and implementation plan, and for Water Board members to ask questions of staff and stakeholders. At the second—the adoption hearing, typically scheduled two months after the testimony hearing—the Water Board will be asked to consider comments, staff responses, and any proposed revisions, and establish the TMDL by adopting the proposed Basin Plan amendment. After adoption by the Water Board, the TMDL will be sent to the State Water Board, the California Office of Administrative Law, and U.S. EPA for approval.

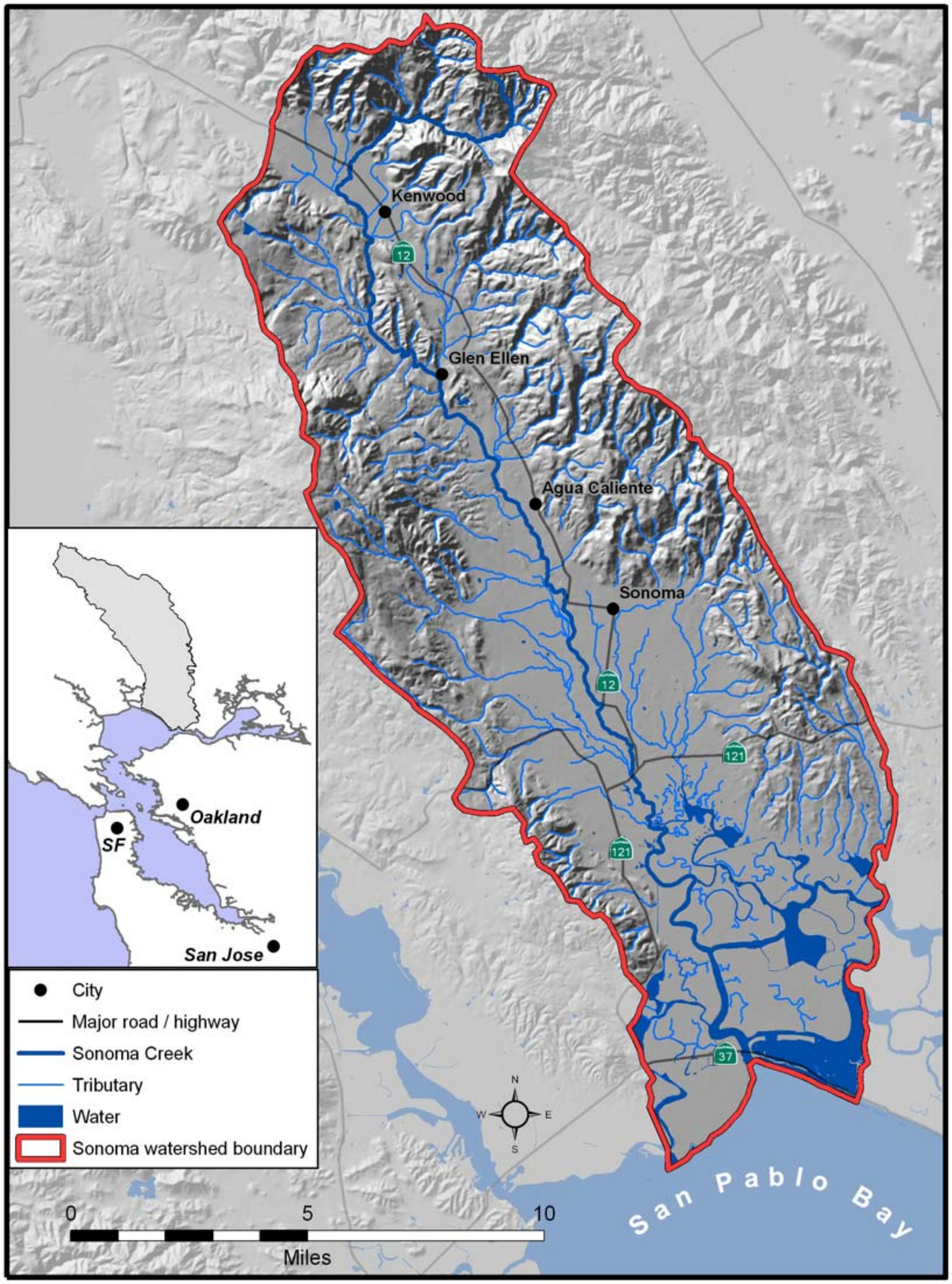
2. WATERSHED DESCRIPTION

The Sonoma Creek watershed is located in the California Coast Ranges north of San Pablo Bay (Figure 1), covering an area of approximately 166 square miles (430 km^2). The main stem of Sonoma Creek flows in a southeasterly direction from headwaters on Sugarloaf Ridge though the Sonoma Valley before discharging to San Pablo Bay. Numerous tributaries enter the main stem from the mountains that rise on both sides of the valley.

Average annual rainfall in the watershed ranges from approximately 23 inches in the lower portions of the Sonoma Valley to greater than 50 inches in the highest slopes of the Sonoma Mountains to the west and Mayacamas Mountains to the east. The large majority of rainfall occurs from November through April, with heaviest rainfall occurring from December through February. This rainfall regime results in two distinct seasons in the watershed. During the winter wet season streamflow and pollutant loading are dominated by precipitation-driven surface runoff. In contrast, groundwater inflow or runoff from human activities dominate during the dry summer months.

Major land cover types in the watershed are forest (approximately 30%), grassland/rangeland (20%), and agriculture (30%, a large and growing percentage of this in vineyards). Developed land—residential, industrial, or commercial—accounts for approximately 15% of the watershed (Association of Bay Area Governments, 2000).

Figure 1.
Location of the Sonoma Creek Watershed



3. PROBLEM DEFINITION

Elevated levels of fecal coliform bacteria have been observed in Sonoma Creek since the 1970s. These bacteria indicate the presence of fecal contamination and attendant health risk to recreational users of the river from water-borne pathogens. Fecal contamination is the primary mechanism for the spread of water-born illness (American Public Health Association, 1998; U.S. EPA, 2001, 2002).

Recent monitoring (Section 3.4) confirmed the presence of elevated Escherichia coli (E. coli; a subset of the fecal coliform group and pathogen indicator) levels in the river and its tributaries. The following sections discuss the use of pathogen indicator bacteria in water quality monitoring and regulation, relevant water quality standards, historic bacterial monitoring in the watershed, and current bacterial water quality studies.

3.1 Use of Fecal Bacteria as Indicators of Pathogens

More than 100 types of pathogenic microorganisms may be found in water polluted by fecal matter and can cause outbreaks of waterborne disease (Havelaar, 1993). Techniques currently available for direct monitoring of specific pathogens in water have several shortcomings that preclude their use in routine water quality monitoring. Some common disease-causing viruses (Hepatitis A virus, Rotaviruses, and Norwalk virus) cannot as yet be detected practically; techniques for the recovery and identification of human enteric viruses (viruses affecting the intestines) often have limited sensitivity, are time consuming, and expensive (U.S. EPA, 2001).

Due to these difficulties, indicator organisms—principally bacteria—are commonly used to assess microbial water quality for recreational use waters. Indicator bacteria colonize the intestinal tracts of warm-blooded animals (including humans) and are routinely shed in animal feces. These organisms are not necessarily pathogenic, but are abundant in wastes from warm-blooded animals and are easily detected in the environment. The detection of these organisms indicates that the environment is contaminated with fecal waste and that pathogenic organisms may be present.

Commonly used bacterial indicators of fecal contamination include total coliforms, fecal coliforms, E. coli, and fecal enterococci. Total coliforms include several genera of bacteria commonly found in the intestines of warm-blooded animals. However, many types of coliform bacteria grow naturally in the environment—that is, outside the bodies of warm-blooded animals. Fecal coliforms are a subset of total coliform and are more specific to wastes from warm-blooded animals, but not necessarily to humans. E. coli are a subset of fecal coliforms, and are thought to be more closely linked to the presence of human pathogens than fecal coliforms (U.S. EPA, 2002). Fecal enterococci represent a different bacterial group from the coliforms, and are also regarded to be good indicators of fecal contamination, especially in salt water (U.S. EPA, 2002).

Although fecal bacteria have historically been the indicator organisms of choice, they have three primary shortcomings: 1) the presence of these indicators does not necessarily mean that human pathogens are present—only that they may be present; 2) bacterial indicators may not have the same levels of survival in the environment as the pathogens for which they are intended to serve as sentinels; and 3) these indicators are not human-specific, and therefore do not fully assess the health risk from human enteric viruses and other human-specific pathogens. The third limitation is of less importance than might be assumed, since fecal contamination from a wide range of non-human species—both domesticated and wild—often carry human pathogens (U.S. EPA, 2002). Despite these shortcomings[1], no practical alternative to the use of fecal indicator bacteria is currently available. The Sonoma Creek Pathogen TMDL uses fecal coliforms and E. coli as pathogen indicators. Use of these indicators is consistent with state water quality criteria and with federal guidance (U.S. EPA, 2002). If in the future better indicator organisms are identified and new standards are put into place for these organisms, this TMDL will be modified accordingly.

Microbial Source Tracking (MST) methods have recently been used to help identify nonpoint sources responsible for the fecal pollution of water systems. These methods involve examining the DNA or antibiotic resistance properties of fecal indicator bacteria to determine if the bacteria originated from humans, domesticated animals, or wildlife (Santa Domingo et al., 2002). Microbial source tracking was not employed in this TMDL for the following reasons:

- This approach is very expensive and time-consuming;
- Results are often imprecise and equivocal; and
- Since both human and non-human fecal contamination is known to pose human health risks (Atwill, 1995; Graczyk et al., 1998; U.S. EPA, 2001) identification of a pathogen source as non-human does not eliminate the need to control the source.

[1] An important additional limitation that applies to ambient sampling for any type of microorganism—including both indicator bacteria and actual pathogenic organisms—is that reported sample values are subject to error resulting from limitations in sampling and analytical methods, and should therefore be regarded as approximations. Sources of error can include non-uniform distribution of target organisms in the water being sampled, differential survival of organisms during sample storage and in the test media, clumping of multiple organisms in the test media (with the result that several organisms are counted as just one), and statistical limitations of the testing procedure. Sampling and analytical procedures are designed to minimize these errors, but even in the best of situations the precision of laboratory analysis for bacteria is low relative to chemical analyses. In many cases the true value for a single sample may range from one-third to three times the reported value (American Public Health Association, 1998). This uncertainty can be considerably reduced through repeated sampling and use of geometric means or medians, rather than single-sample values.

3.2 Water Quality Standards

Water quality standards consist of: a) beneficial uses for the waterbody, b) water quality objectives to protect those beneficial uses, and c) the Antidegradation Policy, which requires the continued maintenance of existing high-quality waters. The Water Board's Basin Plan specifies beneficial uses for waterbodies in the Region and the objectives and implementation measures necessary to protect those beneficial uses. The beneficial uses of Sonoma Creek and its tributaries impaired by high levels of pathogens are water contact recreation (REC-1) and non-contact water recreation (REC-2). These beneficial uses are described in Table 1. The purpose of this TMDL is to protect and restore these beneficial uses by reducing the levels of pathogens in this watershed. Water quality objectives for REC-1 use are more stringent than those for REC-2, since REC-1 can involve water ingestion. Since both beneficial uses occur in Sonoma Creek, this TMDL will be driven by the more rigorous REC-1 requirements.

Table 1
Beneficial Uses of Sonoma Creek and Its Tributaries Potentially Impaired by Pathogens

Designated Beneficial Use	Description (as defined in Basin Plan)
Water Contact Recreation (REC-1)	Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs.
Non-contact Water Recreation (REC-2)	Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where water ingestion is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, bathing, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Table 2 lists the Water Board's Basin Plan numerical water quality objectives for fecal and total coliforms for contact recreation (REC-1). The Basin Plan also cites U.S. EPA bacteriological criteria "to supplement objectives for recreational waters" (Water Board, 1995). The U.S. EPA criteria are presented in Table 3.

Table 3 presents recently recommended criteria for protecting recreational users. The percentile criteria were originally expressed as single sample maximums (U.S. EPA, 1986). The 75th percentile value was applied as a single sample maximum at designated beaches, the 82nd at moderately used areas, the 90th at lightly used areas, and the 95th at infrequently used areas. Reconsideration of the epidemiological data on which these criteria are based and the statistical implications of these data led U.S. EPA to revise the single sample maximum interpretation to a percentile-based interpretation (U.S. EPA, 2002). While the Basin Plan citation still reflects the old U.S. EPA interpretation, Table 3 is based on the newer interpretation.

Table 2 **Water Quality Objectives For Coliform Bacteria**[a]		
Beneficial Use	**Fecal Coliform (MPN[2]/100 mL)**	**Total Coliform (MPN/100 mL)**
Water Contact Recreation (REC 1)	Log mean[b]<200 90th percentile<400	Median< 240 No sample> 10,000
Non-contact Water Recreation (REC 2)	Mean<2000 90th percentile<4000	N/A
a. Based on a minimum of five consecutive samples equally spaced over a 30-day period. b. “Log mean” is in this case synonymous with geometric mean, the latter being the preferred term.		

Table 3 **U.S. EPA Recommended Water Quality Criteria for** **Bacteria in Fresh-Contact Recreational Waters**		
	Enterococci (CFU[a]/100 mL)	**E. Coli (CFU/100 mL)**
Steady State (all areas):	33	126
Percentiles[b]:		
75th	61	235
82nd	89	298
90th	108	406
95th	151	576
a. Colony forming unit (CFU)[3]. b. U.S. EPA does not specify a minimum number of samples upon which to base percentile calculations.		

It is noteworthy that U.S. EPA does not specify criteria for total coliforms in contact recreational waters. As discussed in Section 3.1 above, total coliform bacteria can reproduce in the environment outside the bodies of warm-blooded animals, and are therefore a poor indicator for pathogens in ambient water samples. The use of total coliform as indicators in fresh recreational waters is generally considered obsolete. However, total coliforms are still frequently used to monitor disinfection efficiency in wastewater treatment facilities.

[2] MPN (Most Probable Number) is used here as a unit of measure, equivalent for practical data interpretation and regulatory purposes to CFU, described in the following footnote. The term MPN also describes a laboratory method consisting of a multi-phase laboratory assay followed by a statistical estimate of the number of organisms present.

[3] Throughout the remainder of this document, bacterial counts are expressed as colony forming units (CFU). The term MPN in Table 2 is used in order to be consistent with Basin Plan language. For practical data interpretation and regulatory purposes, MPN and CFU can be considered equivalent *when used as units of measurement*, both referring to the estimated number of viable bacteria in the sample (U.S. EPA, 2001).

3.3 Bacterial Water Quality Studies in the Sonoma Creek Watershed

In 1977 the Sonoma County Water Agency reported fecal coliform densities ranging from 1500 and 4600 CFU/100 mL in Sonoma Creek at Agua Caliente during storm runoff conditions. A recent review of historical data for the watershed reported spring and summer fecal coliform densities at five stations on Sonoma Creek between 1973 and 1988 (Dombeck and Hymanson, 1997). Although only between one and five samples were collected at each site, bacteria levels were highly elevated at all stations except the Highway 12 station located upstream of Kenwood (Table 4).

Table 4
Reported Sonoma Creek Fecal Coliform Densities 1973-1988.

Station Location	minimum	maximum	average	# of samples
Highway 12 above Kenwood	49	49	49	1
Agua Caliente Road	23	24,000	8,031	3
Leveroni Road	24,000	24,000	24,000	1
McGill	490	24,000	12,245	2
Second Napa Slough	310	3,500	1,905	2

Beginning in 2002 the Water Board, in cooperation with the San Francisco Estuary Institute (SFEI), and with laboratory support from U.S. EPA, conducted an intensive study to assess fecal coliform levels in the Sonoma Creek watershed. Nine main-stem sampling stations were sampled in between Sugarloaf State Park and Highway 12, with seven additional tributary stations (Figure 2). Stations were selected randomly (constrained only by the requirement for relatively easy access) with the intent of obtaining a general characterization of the watershed. Sampling was conducted in October 2002, January 2003, and July 2003. The January sampling began approximately one week following a major winter storm event, and was intended to represent stable-flow wet season conditions. The other two events were selected to represent typical dry season conditions. At most of the sites a single sample was collected during each event. In addition, for each event, a subset of five sites was selected for more intensive sampling. Intensive sampling consisted of five samples collected at weekly intervals, allowing calculation of geometric means. Selection of sites for intensive sampling was non-random, and was based on suspected bacterial contamination, or on frequency of contact recreational use.

Results of the Water Board/SFEI study are summarized in Table 5 (raw data are presented in Appendix A). The 2002-2003 data indicate much better water quality than the historical data presented above. The newer results show moderate, somewhat localized impairment. Exceedances of U.S. EPA recommended criteria (geometric mean value of 126 CFU/100 mL) occurred at several locations, during both wet and dry season sampling. The most severe and consistent exceedances were observed on Sonoma Creek downstream of the community of Kenwood, with additional exceedances further downstream on Sonoma Creek, and in the Nathanson/Schell Creek watershed. These results will be discussed in greater detail in the source assessment section of this report.

Figure 2
Sites Monitored in the Water Board/SFEI Study

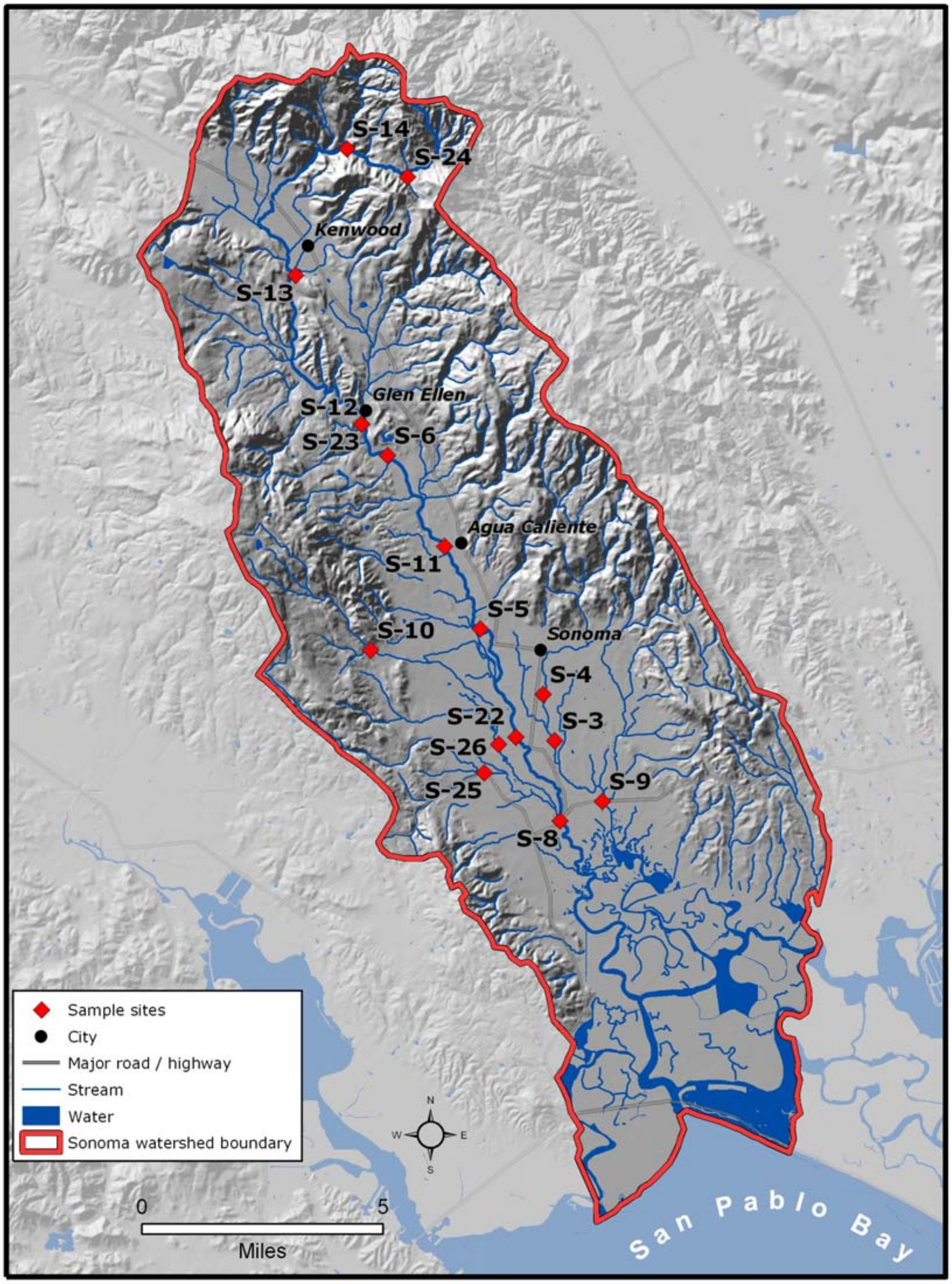


Table 5
E. Coli Densities Observed in the
Water Board/SFEI Study, October 2002–July 2003.

Station	**Location**	**E. coli, CFU/100 ml**		
		Wet Season	**Dry Season**	
		Jan-03	**Jul-03**	**Oct-02**
S-24	**Sonoma Creek at Sugarloaf S.P. Campground**	20	52	dry site
S-14	**Sonoma Creek at Goodspeed Trail in S.P.**	**26**[a]	**16**	**41**
S-13	**Sonoma Creek below Kenwood**	***206***[b]	***562***	***196***
S-23	**Calabazas Creek at Glen Ellen**	31	63	dry site
S-12	**Sonoma Creek at Glen Ellen**	***207***	130	**45**
S-6	**Sonoma Creek at Developmental Center**	***206***	**38**	***128***
S-11	**Sonoma Creek at Agua Caliente**	180	31	10
S-5	**Sonoma Creek at Maxwell Park**	150	**42**	63
S-10	**Upper Carriger Creek**	41	no access	52
S-4	**Nathanson Creek at Nathanson Park**	170	***233***	dry site
S-26	**Carriger Creek at Watmaugh Road**	98	160	dry site
S-22	**Sonoma Creek at Watmaugh Road**	280	150	dry site
S-3	**Nathanson Creek At Watmaugh Road**	110	dry site	dry site
S-25	**Rodgers Creek at Arnold Drive**	31	dry site	dry site
S-9	**Schell Creek at Highway 121**	230	*470*	dry site
S-8	**Sonoma Creek at Highway 121**	***323***	41	***823***

a. Values in bold type represent geometric means of five weekly samples; non-bold values represent single samples.
b. Values in italics represent exceedances of U.S. EPA recommended E. coli criteria.

4. NUMERIC TARGETS

In order to develop a TMDL, a desired or target condition must be established to provide measurable environmental management goals and a clear linkage to attaining the applicable water quality objectives. The numeric targets (desired future conditions for the Sonoma Creek watershed) proposed for this TMDL are as follows:

1. Geometric mean E. coli density of 126 CFU/100 mL;

2. Ninetieth percentile E. coli density of 406 CFU/100 mL; and

3. Zero discharge of inadequately treated human waste to Sonoma Creek and its tributaries.

The first two targets are based on U.S. EPA guidance (U.S. EPA; 1986, 2002) and are referenced in the Water Board's Basin Plan.) U.S. EPA has determined that E. coli densities are more strongly correlated to human illness rates than fecal coliform densities are (U.S. EPA; 1986, 2002). The E. coli targets are therefore considered to be at least as protective as the Basin Plan's fecal coliform-based Water Quality Objectives (presented in Table 2.).

As discussed in Section 3.1, E. coli are a subset of the fecal coliform group of bacteria. It has been established that E. coli typically constitute from 80% to more than 90% of fecal coliforms in fecally contaminated ambient water samples (Noble et al., 2000). Assuming the conservative 80% conversion factor, a geometric mean of 126 CFU/100 mL E. coli is equivalent to approximately 158 CFU/100 mL fecal coliform—lower than the Basin Plan Water Quality Objective of 200 CFU/100 mL fecal coliform. Similarly, a 90th percentile value of 406 CFU/100mL E. coli is approximately equivalent to 507 CFU/100 mL fecal coliform, slightly higher than the Water Quality Objective of 400 CFU/100 mL fecal coliform.

The third target, zero discharge of untreated human waste, is based on the knowledge that fecal bacteria are imperfect indicators of human pathogens. Since direct monitoring of human pathogens is not feasible (see Section 3.1), and since untreated human waste is the most serious potential source of these pathogens, a prohibition of raw or inadequately treated human waste discharge is proposed. This target is consistent with the Basin Plan's region-wide prohibition against the discharge of raw sewage.

These TMDL targets are consistent with water quality objectives or prohibitions included in the Basin Plan. Since these targets are based on conservatively established protective water quality objectives, they contain an inherent margin of safety. The targets are proposed as the desired long-term conditions this TMDL seeks to achieve.

5. POLLUTANT SOURCE ASSESSMENT

Data collected in the Sonoma Creek watershed, as well as similar work conducted elsewhere in the San Francisco Bay watershed, suggest a limited list of possible sources that may contribute significant pathogen loads to the system. Primary potential source categories are described briefly below.

- **Septic systems.** A significant portion of the total watershed population—especially in less densely developed areas—relies on septic systems. The most densely populated portion of the watershed utilizing septic systems includes the community of Kenwood and surrounding areas. The majority of soils in the watershed are classified as having severe restrictions for use as septic tank leach fields, due either to low permeability, slope, depth to bedrock, impermeable layers, or wetness (USDA, 1972). Septic systems—especially older systems—located in these areas are especially prone to failure, and may release pathogens to adjacent surface waters even when system failure is not evident.

- **Sanitary sewer system failures.** Failures occur when untreated sewage is not contained in the sanitary sewer collection system. Failures may be caused by grease buildup in the sewer pipes, structural problems (such as broken/cracked pipes), or increased pressure and flow resulting from infiltration and inflow. In the Sonoma Creek watershed, the more densely populated areas are served by sanitary sewers, with the exception of Kenwood and surrounding areas, which rely on septic systems. No major sewer line failures have been documented in the watershed. However, chronic minor leakage of sewer lines is often difficult to detect, but can result in sustained impairment of adjacent surface waters through bacterial and nutrient loading (U.S. EPA, 1993).

- **Municipal runoff.** Approximately 15% of the watershed is occupied by residential or commercial development (Association of Bay Area Governments, 2000). Urban runoff delivers pathogens to surface waters from domestic animal waste, trash, wildlife, failing septic systems, and in some cases human waste from homeless populations. Homeless encampments are readily observed at a number of locations along Sonoma Creek, and may be an important source of waterborne pathogens.

- **Cattle grazing.** Cattle grazing is widely distributed, occurring from the extreme upper end of the watershed to the most southern end. Grazing has been found to be a significant source of pathogens in nearby watersheds in the region (Water Board 2005a, 2005b).

- **Dairies.** Four dairies currently operate within the Sonoma Creek watershed, all in the southwest section of the watershed. Dairy operations potentially produce large quantities of fecal matter, and may be a significant source of pathogens if appropriate management practices are not in place. Currently, the Water Board regulates all dairies operating in the Sonoma Creek watershed.

- **Wildlife**. Much of the Sonoma Creek watershed remains undeveloped, providing habitat for abundant wildlife. Most warm-blooded animals are capable of carrying pathogen indicator bacteria as well as a wide range of actual human pathogens (U.S. EPA, 2001). Wildlife have been identified as significant pathogen sources in other TMDLs in California, but generally only in locations where there are concentrated populations of wildlife (Central Coast Water Board, 2004; Water Board, 2005a).

- **Domestic wastewater treatment facility discharge.** The Sonoma Valley County Sanitation District facility is the only permitted discharger of municipal wastewater to the surface waters in the Sonoma Creek watershed. The facility discharges to tidal Sonoma Slough in the extreme southern end of the watershed. The facility's National Pollutant Discharge Elimination System (NPDES) permit allows discharge only during the winter months, and limits effluent bacteria levels to a median of 23 CFU/100 mL total coliform.

The following sections examine the distribution and relative importance of these source categories in the Sonoma Creek watershed.

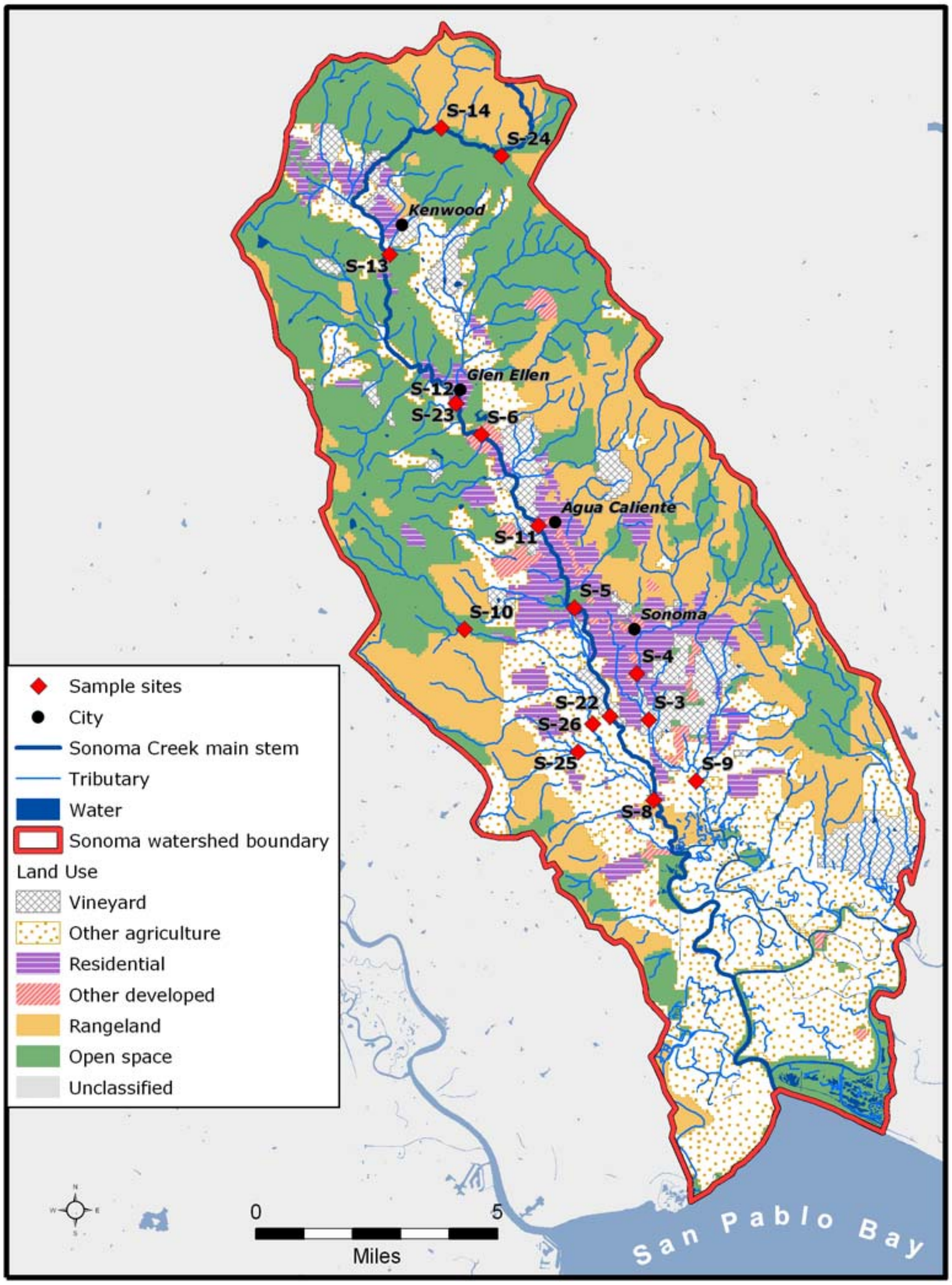
5.1 Analysis of Water Board/SFEI 2002-2003 Data

This discussion explores relationships between the bacteria data collected in the 2002–2003 Water Board/SFEI study (Table 5) and general land uses in the watershed (Figure 3). While the bacterial data are not sufficient in either spatial or temporal resolution to allow quantitative assessment of pathogen loads, the observations presented here support a relative assessment of the importance of different nonpoint source categories.

Bacteria densities were consistently low at the two uppermost sampling sites on Sonoma Creek (S-24 and S-14), both located in Sugarloaf State Park. Both of these sites receive water primarily from park and rangeland. Levels increase markedly at station S-13 below Kenwood, exceeding numeric targets during all sampling events. This station receives water from a mixture of land uses, including vineyards and residential development.

During the wet season, E. coli densities in the main stem generally remained elevated as far downstream as station S-5 at Maxwell Park in the city of Sonoma. In contrast, E. coli levels declined significantly between S-13 and S-5 during the dry season sampling events. Different pathogen delivery mechanisms during the wet and dry seasons may account for this seasonal difference. During the wet season, loading is primarily via precipitation-driven surface runoff, and secondarily through groundwater flow into stream channels. Surface runoff is largely absent in the dry season and pathogen delivery is predominantly though groundwater inflow (possibly including septic system leachate), direct deposition (e.g., animals in the creek), and low-volume runoff from human activities (e.g., lawn and landscape watering, car washing, washing of animal holding areas, etc.). Lower dry season stream velocities also result in longer travel times, which, combined with higher levels of sunlight, result in greater bacterial die-off during the dry season. Thus, it appears that in the dry season bacterial loading is primarily from upstream of S-13, with die-off and dilution resulting in lower downstream bacteria levels. Additional downstream loading (likely via surface runoff) and reduced bacterial die-off appear to maintain relatively high bacteria levels downstream through the City of Sonoma during the wet season.

Figure 3
General Land Cover in the Sonoma Creek Watershed[4]



[4] Based on 1996 Association of Bay Area Governments GIS data (ABAG, 1996).

The upper Carriger Creek station (S-26) was consistently low in indicator bacteria, similar to the upper Sonoma Creek stations mentioned above. The contributing watersheds of all of these stations are notably free of development, and can be considered to represent reference conditions for the watershed. Wildlife would be expected to be abundant at these sites, and the consistently low E. coli values indicate that wildlife do not in general constitute a significant pathogen source in the watershed.

Bacteria levels were also consistently low at the Calabazas Creek station (S-23). Land use upstream of this station is a complex mixture of agriculture (mostly vineyards), residential development (mostly sewered), and open space.

Samples collected in the Nathanson Creek-Schell Creek watershed (S-4, S-3, S-9) showed moderately high E. coli levels both in wet and dry seasons. The S-4 catchment area is primarily in urban land use and is served by sanitary sewer. The S-3 and S-9 catchment areas consist of a mixture of urban, grazing, and agricultural land uses.

Station S-8, the most downstream sampling site on Sonoma Creek, generally receives flow from the town of Sonoma and from agricultural land, including two dairies. Wet season bacteria levels at this site were very modestly elevated relative to upstream stations, and the single July sample was quite low. October 2002 bacteria levels were quite high at this station. However, the October samples do not reflect upstream loading because Sonoma Creek was dry at the time of sampling from a short distance upstream of S-8 through station S-22 at Watmaugh Road. The October S-8 data therefore represent tidal water primarily from downstream of the sample site. The source of the elevated October bacteria levels at S-8 is unclear. Possible sources include wildlife or cattle grazing.

5.2 Supplemental Monitoring 2004-2005

The Water Board conducted supplemental sampling in May 2004 and April 2005 in order to investigate indicator bacteria sources near hotspots identified in the 2002-2003 study. Sampling focused on upper reaches of Sonoma Creek in the vicinity of Kenwood, the Nathanson/Schell Creek system, and on Sonoma Creek below the City of Sonoma (Figures 4 and 5). Samples were collected at additional stations located incrementally upstream (and where possible and appropriate, downstream) of the sites sampled in the earlier study. Samples were also collected in the middle reaches of Sonoma Creek in order to confirm data previously obtained from these sites.

Samples were collected weekly over a five week period. In order to conserve limited laboratory resources, an adaptive, tiered monitoring scheme was employed. All sites were sampled for the first two weeks and the results used to establish a subset of sites for three additional weeks of sampling. Sampling was discontinued at sites that were consistently very low or high for the first two weeks, or were very similar to either upstream or downstream sites.

Figure 4
Supplemental Water Board/SFEI Monitoring Sites—Upper Watershed.

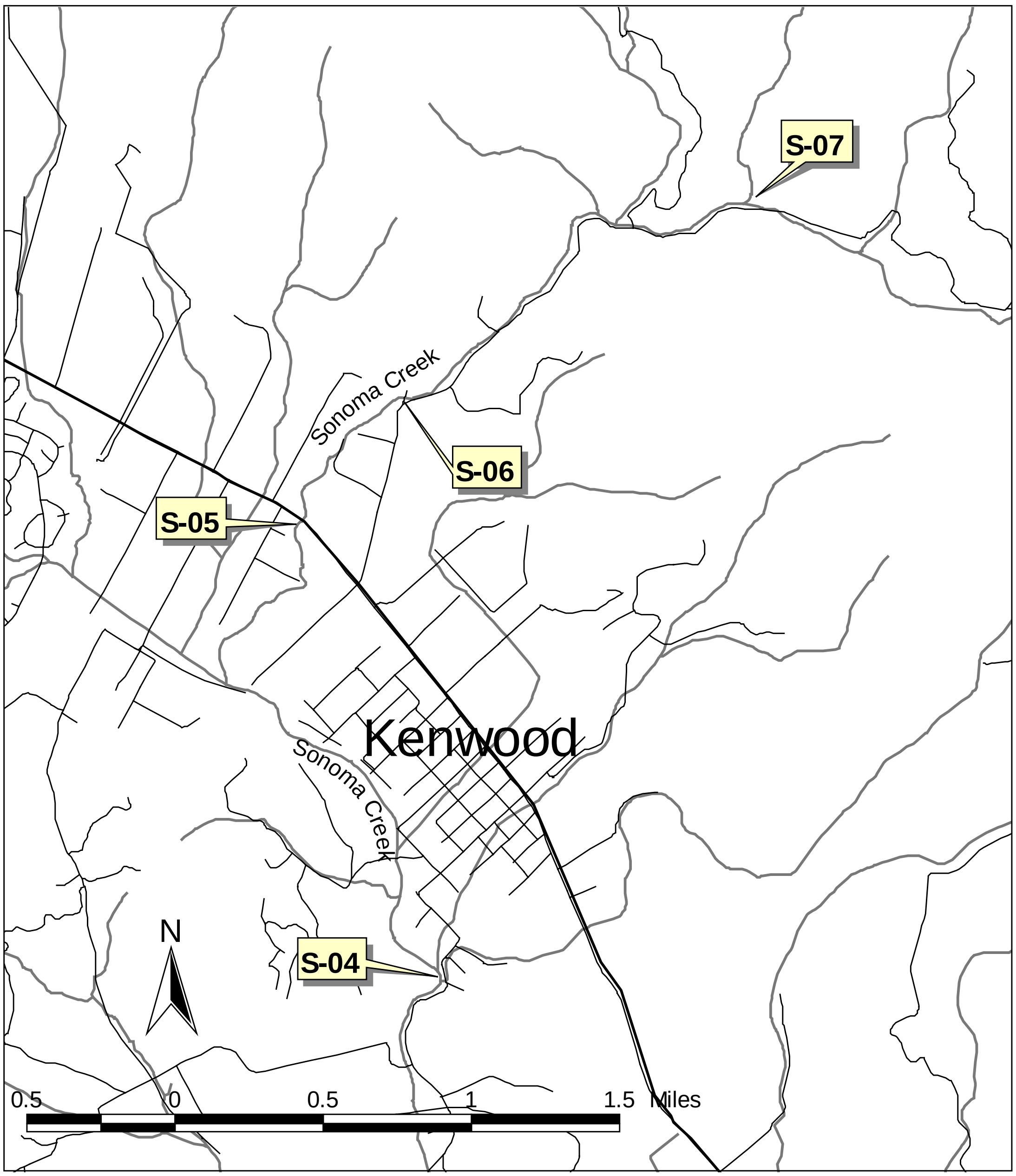


Figure 4
Supplemental Water Board/SFEI Monitoring Sites—Lower Watershed.

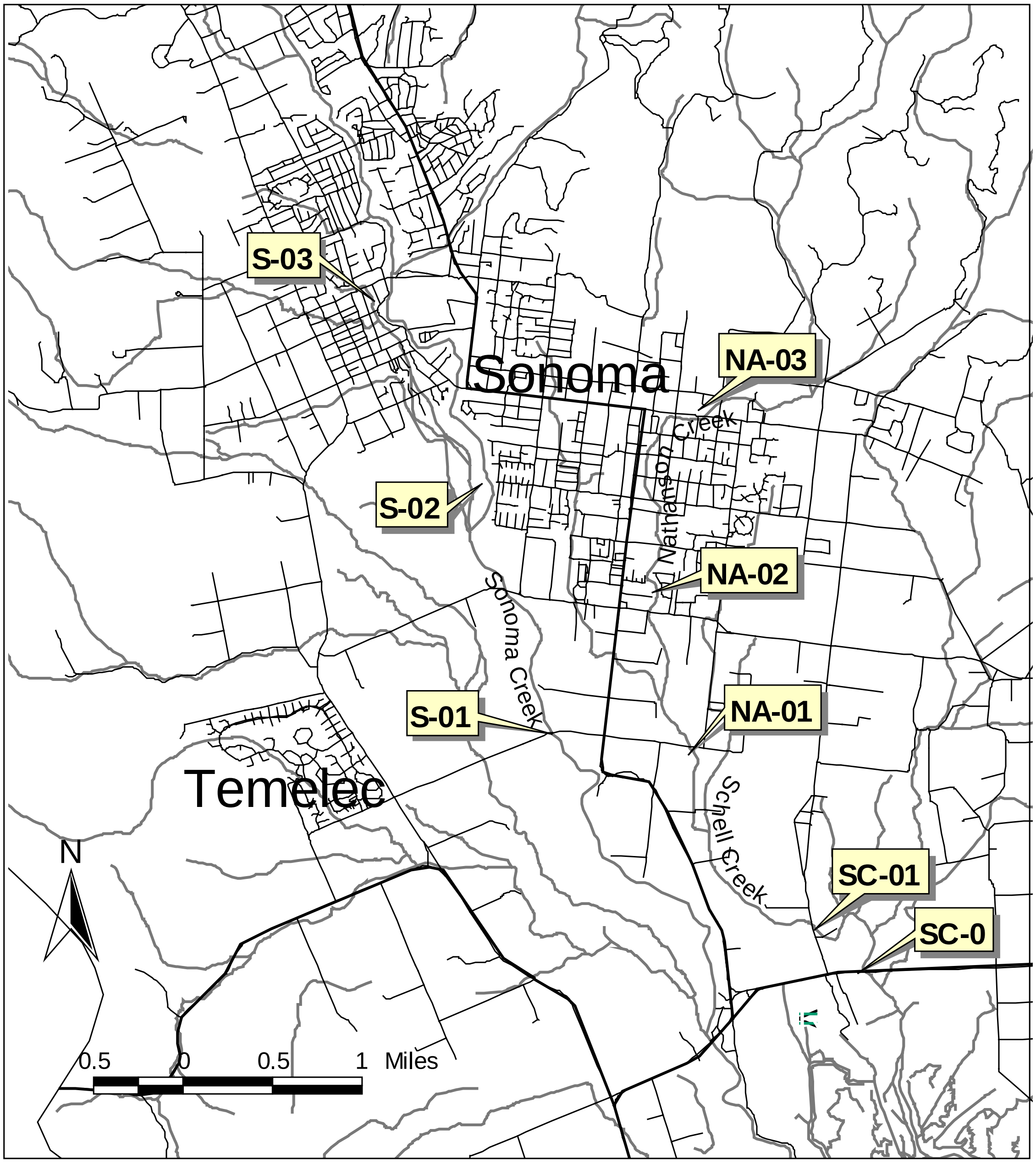


Table 6 May 2004 and April 2005 Supplemental E. Coli Sampling Results			
Site Location	**Site Number[a]**	**E. Coli (CFU/100mL, geometric mean)**	**Number of Weeks Sampled**
May 2004			
Sonoma Creek @ Goodspeed Trail	S-07 (S-14)	10	2
Sonoma Creek @ Adobe Canyon Rd.	S-06	19	5
Sonoma Creek @ Highway 12	S-05	38	5
Sonoma Creek below Kenwood	S-04 (S-13)	147	5
Sonoma Creek @ Maxwell Park	S-03 (S-5)	132	5
Sonoma Creek @ Andrieux St.	S-02	188	3
Sonoma Creek @ Watmaugh Rd.	S-01 (S-22)	237	5
Nathanson Creek @ East Napa St.	NA-03	415	2
Nathanson Creek @ Nathanson Park	NA-02 (S-4)	483	5
Nathanson Creek @ Watmaugh Rd.	NA-01 (S-3)	275	3
April 2005			
Sonoma Creek @ Andrieux St.	S-02	94	5
Sonoma Creek @ Watmaugh Rd.	S-01 (S-22)	131	5
Nathanson @ Nathanson Park	NA-02 (S-4)	237	5
Nathanson @ Watmaugh Rd.	NA-01 (S-3)	206	5
Schell @ 8th St.	SC-01	193	5
Schell @ Highway 121	SC-0 (S-9)	322	5
a. Site numbers from original Water Board/SFEI study are in parentheses.			

May 2004 sampling in the upper Sonoma Creek watershed confirmed the primary observation from the 2002-2003 sampling: markedly elevated E. coli densities below Kenwood. E. coli counts at the three stations upstream of Kenwood were uniformly low, with a statistically significant[5] increase at S-04 (Figure 4, Table 6). Bacteria densities downstream through Sonoma Creek at Watmaugh Road (S-01) remained above numeric targets, and were not significantly different from levels observed at S-04. If all loading were from upstream of S-04, downstream densities would be expected to decline due to dilution and/or die-off. The data suggest modest additional bacterial loading to Sonoma Creek from sources between Kenwood and Watmaugh Road.

[5] In contrast to the 2002-2003 study, the 2004 and 2005 monitoring involved at least two (and usually five) samples from each site, allowing statistical comparisons among sites. Comparisons were performed on log-transformed E. coli densities using Student's T-test, α=0.05. Since the intent of statistical analysis in this instance was to locate E. coli sources within sub-watersheds, rather than to compare sub-watersheds, comparisons were made only within sampling periods (i.e., May 2004 or April 2005) and within sub-watersheds (e.g. sites on Sonoma Creek were compared to other sites on Sonoma Creek, but not with sites on Nathanson Creek).

Bacteria levels in the Nathanson/Schell Creek watershed were consistently above numeric targets both in 2004 and 2005, similar to the 2002-2003 data. There were no statistically significant differences among sites in this watershed. As with Sonoma Creek, bacteria levels would be expected to decline from upstream to downstream due to die-off and dilution if loading were exclusively from above the most upstream sampling site. Since no decline is seen, it appears that bacterial loading occurs at multiple locations in this watershed.

Station N-03, the uppermost sampling site in the Nathanson/Schell system, is in a highly urban, sewered location within the City of Sonoma. While the headwaters of Nathanson Creek are dominated by open space and rangeland north of Sonoma, streamflow was extremely low at the time of sampling, and it is unlikely that there was continuous flow from the upstream rangeland to the urban areas surrounding N-03. It therefore appears that the elevated E. coli levels observed at N-03 are of urban origin, the most likely source during this dry season sampling period being dry weather urban runoff or leakage from nearby sewer lines.

The areas surrounding the sampling sites in the lower portions of the Nathanson/Schell watershed (NA-01, SC-01, SC-0) are relatively free of residential development. Cattle grazing is a significant land use in this area and is a likely source of the elevated E. coli values seen at these stations.

5.3 Upper Sonoma Creek Nitrate Data

Failing or inappropriately sited septic systems are widely recognized to be major sources of nitrate pollution (LaPointe et al., 1990 ; U.S. EPA, 1999). Therefore, nitrate data collected by the San Francisco Estuary Institute during the 2002, 2003, and 2004 E. coli monitoring events sheds further light on pathogen sources in the upper reaches of Sonoma Creek. The data show a dramatic increase in nitrate concentrations below Kenwood in all seasons (Table 7). Nitrate levels decline downstream in the dry season sampling events, but remain elevated in the wet season. The dry season pattern is consistent with a single major source upstream of S-04 combined with nitrate uptake and dilution downstream, while wet season data suggest a major source above S-04 and additional (likely runoff-related) nitrate sources downstream.

Other common nitrate sources include agricultural runoff and livestock operations. Agricultural runoff is not generally a source of pathogens, and livestock operations do not currently occur in the upper reaches of Sonoma Creek. The simultaneous increases in E. coli and nitrate levels downstream of Kenwood therefore constitute overwhelming evidence that septic systems in this community are a major pathogen source. The Sonoma Creek watershed is also listed as impaired by nutrients, and these data indicate that septic systems in the vicinity of Kenwood constitute a significant source of nutrients as well.

Table 7 Nitrate Concentrations in Upper and Middle Sonoma Creek.					
Station	Location	Nitrate-N, μg/L			
		Oct-02	Jan-03	Jul-03	May-04
S-07	Sonoma Creek at Goodspeed Trail in S.P.	67	116	166	203
S-05	Sonoma Creek at Highway 12				72
S-04	Sonoma Creek below Kenwood	1,059	2,091	1,619	2,052
S-12	Sonoma Creek at Glen Ellen	29	960	1,612	
S-6	Sonoma Creek at Developmental Center	18	437	1,495	
S-11	Sonoma Creek at Agua Caliente	15	129	1,442	
S-5	Sonoma Creek at Maxwell Park	2	102	1,454	597

5.4 Source Assessment Summary

Due to data and resources limitations, this report does not quantitatively estimate loads for the different pathogen sources in the Sonoma Creek watershed. However, the data discussed above allow for general conclusions on the importance and magnitude of the different types of pathogen sources described at the beginning of this section. The following source categories potentially contribute significant controllable pathogen loads in the watershed, and these sources will be addressed in the preliminary implementation plan presented later in this report:

- **Septic systems**. This source category appears to be a significant source of pathogen loading, especially during the dry season. Bacteria and nitrate data combine to provide very strong evidence that septic tanks in the vicinity of Kenwood contribute to pathogen loading in upper Sonoma Creek.

- **Sanitary sewer system failures.** Elevated dry season indicator bacteria levels were observed in sewered areas of Nathanson Creek and Sonoma Creek. Due to these observations and the nationwide prevalence of sewer line exfiltration (U.S. EPA, 1993), sanitary sewer system failures are considered a potentially significant pathogen source in this watershed. Additional monitoring during the implementation phase of this TMDL will be required to further assess the importance of this source category.

- **Municipal runoff.** Data indicate that urban stormwater is a significant, widespread wet season pathogen source in the watershed. Urban areas in the watershed are associated with elevated wet season indicator bacteria densities.

- **Cattle grazing.** Elevated indicator bacteria levels may be associated with cattle grazing in the lower portions of the watershed. In view of this observation and observations elsewhere in the region (Water Board 2005a, 2005c) cattle grazing is considered a potentially significant source of pathogens in this watershed. The extent and severity of this source category should be clarified through further monitoring during adaptive TMDL implementation.

- **Dairies.** Four dairies currently operate within the Sonoma Creek watershed, all located in the southwest section of the watershed. Currently, the Water Board via NPDES Permit or Waivers of Waste Discharge Requirements regulates all dairies operating in the Sonoma Creek watershed. If not properly managed, dairies have the potential to discharge pathogens to Sonoma Creek. Possible mechanisms of discharge include direct discharge by cows and failure of waste ponds.

- **Wildlife.** The low indicator bacteria levels observed at sampling sites that are not heavily affected by human activity indicates that wildlife are not, in general, a significant pathogen source in this watershed. Local problems may be present in certain areas where wildlife densities are particularly high.

- **Domestic wastewater treatment facility discharge.** Recent self-monitoring reports from the Sonoma Valley County Sanitation District treatment facility indicate that facility effluent is well below numeric targets and does not significantly contribute to pathogen loading under normal conditions.

6. TOTAL MAXIMUM DAILY LOAD AND LOAD ALLOCATIONS

6.1 General Approach

U.S. EPA guidelines (U.S. EPA, 1991) for developing TMDLs define the maximum allowable pollutant load as the total load of a particular pollutant that can be present in a waterbody while still attaining and maintaining designated beneficial uses. TMDLs for a waterbody are the sum of individual wasteload allocations for point sources and load allocations for nonpoint sources. The sum of these components must not result in the exceedance of water quality standards for that waterbody. In addition, the TMDL must include a margin of safety (MOS), either implicit or explicit, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody.

For most pollutants, TMDLs are expressed on a mass-loading basis (e.g., pounds per day, organisms per day). The Code of Federal Regulations (40 CFR § 130.2(1)) states that TMDLs do not need to be expressed as loads (mass per unit time), but may be expressed as "other appropriate measure." For pathogen indicators, it is the number of organisms in a given volume of water (i.e., their density), and not their mass or total number that is significant with respect to public health and protection of beneficial uses. The density of fecal indicator organisms in a discharge and in the receiving waters is the technically relevant criterion for assessing the impact of discharges, the quality of the affected receiving waters, and the public-health risk. Therefore, this TMDL plan establishes density-based TMDLs and pollutant load allocations, expressed in terms of indicator bacteria densities.

Establishment of a density-based, rather than a load-based TMDL carries the advantage of eliminating the need to conduct a complex and potentially error-prone analysis to link loads and expected densities. A load-based TMDL would require calculation of acceptable loads based on acceptable bacterial densities and expected flows, and then back-calculation of expected densities under various load reduction scenarios. Since flows in Sonoma Creek, and especially in its tributaries, are highly variable and difficult to measure, such an analysis would inevitably involve a great deal of uncertainty, with no increased water quality benefit.

6.2 Proposed Total Maximum Daily Loads

Proposed TMDLs for the Sonoma Creek watershed are listed in Table 8. These TMDLs will be applicable year-round. As shown, the TMDLs are the density-based REC-I water quality objectives and U.S. EPA-recommended water quality criteria for contact recreation (Tables 2 and 3 [water quality objectives tables from Section 3.2]). This TMDL represents the total number of fecal indicator bacteria that can be discharged from all sources while not causing the water quality in the tributaries to exceed the bacterial densities specified in the Basin Plan.

Table 8 Total Maximum Daily Loads for the Sonoma Creek Watershed	
Indicator	**TMDL (CFU/100 mL)[a]**
E. coli	Geometric mean < 126 90^{th} percentile < 406

[a]Based on a minimum of five samples collected within a 30-day period.

6.3 Proposed Load and Wasteload Allocations

Density-based load allocations are proposed for this TMDL. Unlike mass-based load allocations, the density-based load allocations do not add up to equal the TMDL, since the densities of individual pollution sources are not additive. Rather, in order to achieve the density-based TMDL, it is simply necessary to assure that each source meets the density-based overall load allocation (Santa Ana Water Board, 1998; Central Coast Water Board, 2002).

Table 9 presents the density-based pathogen load and wasteload allocations proposed for the Sonoma Creek watershed. These load allocations will apply year-round to the different source categories of pollution in the watershed. The attainment of these load allocations will ensure protection of the water quality and beneficial uses of Sonoma Creek and its tributaries.

Table 9 Density-Based Pollutant Load Allocations for Different Pollution Source Categories[a]		
Categorical Pollutant Source	**E. coli Density, CFU/100 mL**	
	Geometric Mean	90^{th} Percentile
Sanitary Sewer System Overflows	0	0
Septic Systems	0	0
Municipal Runoff	<126	<406
Cattle Grazing	<126	<406
Dairies	<126	<406
Wildlife	<126	<406

a. The allocations in this table are not additive (see text).

The proposed wasteload allocation for the Sonoma Valley County Sanitation District facility is equivalent to the effluent limits specified in the facility's NPDES discharge permit (Table 10). These limits are expressed as total coliform bacteria, a superset of the E. coli group. The limits are conservative, and represent minimal pathogen loading to Sonoma Creek and its tributaries.

Table 10 Wasteload Allocation for the Sonoma Valley County Sanitation District Facility	
Median Total Coliform	**Maximum Total Coliform**
23 CFU/100 mL	240 CFU/100 mL

In the case of allocations specified by source category, it is the responsibility of individual facility or property owners within a given source category to meet these allocations. In other words, individual facilities and property owners shall not discharge or release a load of pollution that will increase the density of E. coli in the downstream portion of the nearest waterbody above the proposed load allocations assigned to that source type. This allocation scheme assumes that the concentration of E. coli upstream from the discharge point is not in excess of the assigned load allocations. For example, the geometric mean of E. coli concentrations in stormwater runoff samples collected at a residential area's storm drain that discharges into a tributary shall not exceed the allocated loads listed for the urban runoff source category.

Septic systems and sewer line failure, the primary potential sources of untreated human waste to Sonoma Creek and its tributaries, are assigned load allocations of zero for the following reasons:

- As sources of human waste (as opposed to animal waste) they pose the greatest threat to the public health;
- The zero load allocation is consistent with the existing Basin Plan prohibition of release of untreated sewage;
- When operated properly and lawfully, septic systems and sanitary sewer systems should not cause any human waste discharges; and,
- Human waste discharges from these sources are fully controllable and preventable.

For these reasons, zero load allocations for these source categories are both feasible and warranted.

6.4 Margin of Safety

TMDLs are required to include a margin of safety (MOS) to account for data uncertainty, growth, critical conditions, and lack of knowledge. Virtually all pathogens have a limited ability to survive outside the human (or other host) body (U.S. EPA, 2001). Pathogen densities are therefore expected to only decrease in the outside environment over time, due to factors such as exposure to sunlight, chemical damage, and predation/competition by native nonpathogenic organisms. This effect provides an implicit MOS to the proposed TMDL.

Specification of numeric targets and load allocations in terms of U. S. EPA's E. coli recommendations provides an implicit margin of safety, since these recommendations are conservatively derived, and are more protective of human health than fecal coliform-based water quality objectives. Therefore, no additional and/or explicit margin of safety is needed for this TMDL.

6.5 Seasonal Variation

While pathogen loads are typically greatest during the winter wet season due to high volumes of surface runoff, indicator bacteria densities can be high at any time of year. Dry season densities were higher than wet season densities at a number of sites monitored in the Water Board/SFEI study.

Recreational use of Sonoma Creek and its tributaries is most prevalent during the summertime, but can occur at any time of year. Therefore, no seasonal variations to the above-listed TMDLs and load allocations are proposed.

7. LINKAGE ANALYSIS

An essential component of developing a TMDL is to establish a relationship (linkage) between pollutant loadings from various sources and the numeric targets chosen to measure the attainment of beneficial uses. For this TMDL, the proposed load allocations protect the beneficial uses (the linkage is established) because:

- Fecal waste from warm-blooded animals can contain pathogens;
- Fecal coliform bacteria are present fecal waste from warm-blooded animals and are routinely used as a monitoring surrogate;
- The proposed density-based load allocations are the same as, or more stringent than proposed numeric water quality targets;
- The proposed numeric targets are the same as current U.S. EPA recommended bacterial water quality criteria for recreational waters; and
- The U.S. EPA recommended criteria are conservatively based on epidemiological studies (U.S. EPA, 2002) and are protective of beneficial uses.

Therefore, achievement of the proposed pollutant load allocations (listed in Section 6) will ensure the protection of the water quality and beneficial uses of Sonoma Creek and its tributaries.

There is no need to perform transport and fate analysis of pathogen loadings because numeric targets apply at all points in the watershed. That is, any potential pathogen source must meet numeric targets at the point at which the source enters Sonoma Creek or any of its tributaries. Since pathogen regrowth is very unlikely in this watershed, and net pathogen die-off is virtually certain, pathogen densities at any point downstream of the initial point of discharge will be lower than at the point of discharge (see Section 6.4, Margin of Safety).

8. PUBLIC PARTICIPATION

Public participation and stakeholder buy-in is vital to the success of implementing a TMDL. Release of this TMDL project report is an opportunity for the public to provide input to the Water Board. The TMDL will be formally established when it is adopted via a public process as an amendment to the Basin Plan.

8.1 Formal Process for Public Participation

A draft basin plan amendment and the supporting staff report will be presented to the Water Board for review and adoption in the first half of 2006. Two public hearings, a testimony hearing and an adoption hearing, will be held before the Water Board, which will consider adoption of the TMDL into the Basin Plan. This process will allow the public to formally comment on the TMDL. In addition, we will hold a CEQA scoping meeting and public meeting to solicit response to this preliminary project report in December 2005.

8.2 Informal Process for Public Participation

Our pathogen TMDL stakeholder process builds upon the existing sediment TMDL stakeholder framework. We have participated in combined sediment-nutrient-pathogen TMDL meetings since 2002, beginning with a public meeting in November of that year. We maintain continuing involvement with the Sonoma Creek TMDL Steering Committee, Sonoma Ecology Center, the Sonoma County Resource Conservation District, and with local, county, state, and federal agencies involved in the watershed. We are available to attend and/or conduct additional meetings as needed or requested.

9. IMPLEMENTATION PLAN

9.1 Overview

TMDLs are strategies to restore clean water. Implementations plans specify actions needed to solve the problem and are required under California Law. The following implementation plan describes existing regulatory controls and cites relevant sections of the California Water Code (CWC) establishing the Water Board's authority to enforce the provisions set forth in the Implementation Plan. Section 13242 of the CWC requires that an implementation plan be incorporated into the Basin Plan upon Water Board adoption of the final TMDL Basin Plan amendment.

The implementation plan presented in this report provides a general description of proposed actions necessary to achieve water quality objectives. A more detailed implementation plan will be presented in the proposed Basin Plan amendment and accompanying staff report, scheduled for completion in 2006. These documents will contain more detailed descriptions of necessary actions, as well as a time schedule for these actions, and a description of the compliance monitoring and surveillance to be undertaken to ensure successful implementation. Water Board staff will make an effort to discuss source control actions with all interested stakeholders and seek their input in regard to cost and feasibility.

The overall intent of this implementation plan is to restore and protect beneficial uses of Sonoma Creek and its tributaries by reducing pathogen loadings. Potential pathogen sources in the watershed include: septic systems, sanitary sewer system failures, municipal runoff, cattle grazing, and wildlife. The Water Board recognizes the technical, institutional, and monetary challenges that each source category may face in designing and implementing measures to reduce their respective loading. As such, we are trying to be as flexible as possible in the implementation approach for reducing pathogen loading. We anticipate that enforcement mechanisms will only be needed where individuals have chosen not to assess and reduce their potential to impact water quality.

This implementation plan describes the Water Board's regulatory authority (Section 9.2) as well as other plans and policies in the Sonoma Creek watershed that affect pathogen source management activities (Sections 9.3 and 9.4). A description of the proposed implementation actions is provided in Section 9.5. Evaluation of progress toward attaining implementation goals is described in Section 9.6, and a long-term water quality monitoring program is discussed in Section 9.

9.2 Legal Authorities and Requirements

The Water Board has the responsibility and authority for regional water quality control and planning per the state's Porter-Cologne Water Quality Control Act. The Water Board regulates point source pollution by implementing a variety of programs, including the NPDES Program for point sources discharging into waters of the United States. The State also controls nonpoint source pollution as specified in the state's *Plan for California's Nonpoint Source Pollution Control Program* (State Board, 2000; hereafter referred to as the State NPS Management Plan). The State's Porter Cologne Water Quality Control Act gives the Water Board authority to issue Waste Discharge Requirements (WDRs) for point and nonpoint sources of contamination.

9.3 California Nonpoint Source Program

California's Nonpoint Source (NPS) Pollution Control Program has been in effect since 1988 (WMI Chapter, 2001). The NPS Program is a regulatory strategy aimed at addressing nonpoint source pollution throughout the State of California. The NPS program is being revised to enhance efforts to protect water quality, and to conform to the Clean Water Act Section 319 (CWA 319) and the Coastal Zone Act Reauthorization Amendments Section 6217 (CZARA). The lead state agencies for the NPS Program are the State Water Board, the nine Regional Water Boards and the California Coastal Commission. The NPS Program's long-term goal is to "improve water quality by implementing the management measures identified in the California Management Measures for Polluted Runoff Report (CAMMPR) by 2013."

The State also has a Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program that requires current and proposed nonpoint source discharges to be regulated under waste discharge requirements (WDRs), waiver of waste discharge requirement, Basin Plan prohibition, or some combination of these tools (State Board, 2004). For each source category that is currently discharging but not yet regulated, a regulatory tool has been identified.

9.4 Plans & Policies in the Sonoma Creek Watershed

Below is a description of the current regulations, policies, and plans for each of the categorical pathogen sources in the Sonoma Creek watershed. Source categories of concern include:

- Faulty septic systems
- Sanitary sewer line failure
- Municipal runoff
- Cattle grazing
- Dairies

<u>Septic systems</u>
The Water Board's Basin Plan specifically addresses water quality issues related to onsite wastewater treatment and dispersal systems (onsite septic systems). In 1978, the Water Board

adopted a Policy on Discrete Sewerage Facilities enumerating the following principles, which apply to all wastewater discharges:

- The system must be designed and constructed so as to be capable of preventing pollution or contamination of the waters of the State or creating a nuisance for the life of the development project;
- The system must be operated, maintained, and monitored so as to continually prevent pollution or contamination of the waters of the State and the creation of a nuisance;
- The responsibility for both of the above must be clearly and legally assumed by a public entity with the financial and legal capability to assure that the system provides protection to the quality of the waters of the State for the life of the development project.

The policy also makes the following requests of city and county governments:

- That the use of new discrete sewerage systems be prohibited where existing community sewerage systems are reasonably available;
- That the use of individual onsite systems for any subdivision of land be prohibited unless the governing body having jurisdiction determines that the use of the individual onsite systems is in the best public interest and that the existing quality of the waters of the State is maintained consistent with the State Water Board's Resolution 68-16; and,
- That the cumulative impacts of individual onsite system discharges be considered as part of the approval process for development.

The Water Board has conditionally delegated authority for permitting and regulation of individual onsite wastewater treatment systems in Sonoma County to the county government. Delegation was enacted in 1964 by means of the Board's Resolution No. 599, which waives the requirement for filing reports of waste discharge with the Board for systems that are appropriately permitted by the County. In addition, in 1994, the Water Board and the County established a formal Agreement for the County's permitting and regulation of non-standard onsite systems. Onsite systems in Sonoma County are regulated by the Sonoma County Permit and Resource Management Department, in accordance with County Code and associated Regulations. The Code and Regulations include specifications for on-site system siting, design, installation, inspection and repair, and provisions for permitting and enforcement of violations.

In 2000, the California Water Code was amended to require the State Water Board to develop statewide regulations or standards for permitting and operation of onsite wastewater treatment systems (CWC Sections 13290 to 13291.7). The regulations are required to address, in part, new systems, systems subject to major repairs, systems adjacent to 303(d)-listed impaired waters, and minimum requirements for monitoring to determine system performance. Following adoption of the regulations, onsite system programs at both the Regional Water Board and County level will need to be updated to incorporate and implement the new requirements. The State Water Board is working on these regulations. An Initial Study as part of the environmental impact review process for the regulations was distributed for public review and comment in June and August 2005. The Initial Study included a proposed draft of the regulations. The State Water Board is currently working on responses to comments received, revisions to the draft regulations, and development of an Environmental Impact Report. The Initial Study anticipated adoption of the regulations by summer of 2006, and implementation beginning in early 2007.

Sanitary sewer system failures

An October 2003 Water Board resolution (No. R2-2003-0095) established a collaborative program between the Water Board and Bay Area Clean Water Agencies (BACWA) to reduce sanitary sewer overflows (SSOs). The collaborative program includes four key tasks:

- Establish SSO reporting guidelines,
- Develop an electronic reporting system,
- Establish guidelines for sewer system management plans (SSMP) and
- Conduct a series of regional workshops to provide training on the first three tasks.

Reporting guidelines, the electronic reporting system, and regional workshops were completed in 2004. The Water Board in cooperation with BACWA completed the Sewer System Management Plan (SSMP) Development Guide in July 2005. Some of the SSMP requirements direct wastewater agencies to:

- Develop an overflow emergency response plan to contain overflows and prevent wastewater from reaching surface waters,
- Develop a Fats, Oils, and Grease (FOG) Control Program if needed,
- Allocate adequate resources for the operation, maintenance, and repair of its collection system,
- Prioritize preventive maintenance activities, such as scheduled cleaning of sewers, root control, and investigation of customer complains;
- Identity structural deficiencies and prioritize repair, and
- Monitor the effectiveness of each SSMP element.

The Water Board notified wastewater collection agencies of the requirements for preparing SSMPs in July 2005, and the notification included required completion dates for each SSMP element.

Cattle grazing

The State Water Board and the California Coastal Commission have identified management measures to address nonpoint source pollution from grazing activities. In response to nonpoint source pollution concerns, the Range Management Advisory Committee composed of livestock industry representatives and public members was formed. The Committee developed a California Rangeland Water Quality Management Plan, which recommends that ranchers complete rangeland Water Quality Management Plans for their respective ranches. Three approaches for voluntary compliance with the plan include: letter of intent with local Resource Conservation District office; development of a nonpoint source management plan; or adoption of a recognized nonpoint source management plan.

In May, 2004 the State Water Resources Control Board adopted a *Policy for Implementation and Enforcement of the Nonpoint Source Control Program*. This policy requires that the Water Boards regulate all nonpoint sources of pollution by issuing waste discharge requirements or establishing conditions for waiving waste discharge requirements or discharge prohibitions that dischargers must comply with.

Dairy facilities

Minimum design and management standards for the protection of water quality from these animal operations are promulgated in Title 23, California Code of Regulations, Chapter 15, Article 6. These regulations prohibit the discharge of facility wash water, animal wastes, and stormwater runoff from animal confinement areas into waters of the state. They also specify minimum design and waste management standards for the:

- Collection of all wastewaters;
- Retention of water within manured areas during a 25-year, 24-hour storm event;
- Use of paving or impermeable soils in manure storage areas; and,
- Application of manures and wastewaters on land at reasonable rates.

The Water Board has the authority to enforce these regulations through Waste Discharge Requirements (WDRs). Dairies are the typical animal confinement operation within the Watershed. The Water Board issued a Waiver of Waste Discharge Requirements for dairies (Resolution No 83-3) that have proper waste control facilities in place and whose management practices conform with the California Code of Regulations: Title 23, Article 3, Chapter 15 (Discharge of Waste to Land). This waiver expired in January 2003. In 2004, the Water Board renewed the Waiver of Waste Discharge Requirements for Confined Animal Facilities (Resolution No. R2-2003-0094) and completed its assessment of each dairy's compliance with the waiver.

In 1990, the State Board established a Dairy Waste Task Force to look at the dairy industry statewide and develop standards for dairy regulation. The main emphases have been on developing better communication and guidance materials for the industry; developing a dairy survey form to help the Water Board determine if a dairy qualifies for a WDRs waiver; determining the number and location of dairies; developing more-uniform WDRs; and preparing an outreach program aimed at the dairy industry, local government, and the public. The State Water Board members directed staff to continue the following activities:

- Work with the dairy industry through the local dairy waste committees, county farm bureaus, Resource Conservation Districts (RCDs), and other local/state agencies in obtaining cooperative correction of dairy waste problems.
- Recommend adoption of WDRs in those cases in which water quality objectives for waters within an agricultural watershed are consistently exceeded, or in which corrective action is unsuccessful in eliminating either the short- or long-term water quality problems or threats.
- Monitor compliance with animal waste guidelines and WDRs waiver.

Municipal runoff

The Water Board has a comprehensive runoff control program that is designed to be consistent with Federal regulations (40 CFR 122-24) and is implemented by issuing NPDES permits to owners and operators of large storm drain systems and systems discharging significant amounts of pollutants. Each stormwater permit requires that the entities responsible for the system develop and implement comprehensive control programs. The County of Sonoma and the Sonoma County Water Agency are covered by the general stormwater permit issued by the State Board and enforced by the Regional Water Board.

Current municipal runoff program requirements include the following elements:

- Develop, implement, and enforce a stormwater management plan (SWMP) to reduce the discharge of the pollutants to the maximum extent practicable;
- Address specific program areas, including public education and outreach on stormwater impacts, public involvement, illicit discharge detection and elimination, construction site stormwater runoff control, post construction stormwater management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations;
- Evaluation and assessment of measures; and
- Monitoring and reporting.

9.5 Proposed Pathogen Reduction Implementation Actions

This section describes potential management measures for each source category in the Sonoma Creek watershed. In most cases, implementation efforts should focus on these source categories in those portions of the watershed associated with bacterial water quality impairment as identified through the data presented earlier in this report or through future monitoring activities discussed in Section 9.6.

To determine the appropriate level and type of source control and regulatory actions necessary to achieve water quality objectives, the Water Board will consider the following factors:

- The feasibility of achieving the required level of performance (assigned pollutant load allocations) for each source;
- The magnitude of the water quality impairment caused by each source; and
- The history of source control efforts and regulatory requirements.

Feasibility is a function of the technical capability and cost of management measure implementation. Water quality impairment is a function of the type of source (i.e. human versus animal waste) and its potential for causing an exceedance of water quality objectives.

Discharging entities will not be held responsible for uncontrollable coliform discharges originating from wildlife. If wildlife contributions are determined to be the cause of exceedances, the TMDL targets and allocation scheme will be revisited as part of the adaptive implementation program.

Many implementation activities are already underway in the watershed. The Water Board strongly supports these activities and recommends that these efforts be continued. Implementation of pathogen control measures that also reduce sediment and nutrient loads are encouraged, as this may preclude the need for implementation of additional management measures for those sources.

All sources are required to identify potential pathogen sources on their facilities and develop a plan for reducing pathogen runoff. Sources must then implement site-specific management measures to reduce the pathogen run-off and document the measures taken.

Each source category will provide documentation on progress made toward implementation of control measures. In some cases it may be desirable to identify an appropriate third party with expertise in implementation that could help evaluate reports for each source category. Where a third party is not identified, the Water Board will independently assess compliance. In all cases, the discharger is ultimately responsible for implementing identified control measures.

Throughout the TMDL process, the Water Board and stakeholders in the Watershed will need to monitor compliance with management measure implementation and assess whether water quality is improving. The Implementation Plan includes steps for evaluation and follow-up for assessing compliance with the TMDL. Ultimately, the long-term success of the TMDL implementation plan will be measured by attaining the designated TMDL load allocations.

If reasonable progress toward implementing the management practices is not demonstrated, the Water Board will consider additional regulatory control or taking enforcement actions on those source categories and/or individual dischargers that are not participating in good faith. Examples of additional regulation include requiring permits for individual grazing lands or equestrian facilities or requiring operating permits for all septic systems.

If it is demonstrated that reasonable and feasible management measures have been implemented for a sufficient period of time and TMDL targets are still not being met, the TMDL will be reevaluated and revised accordingly.

Table 11 presents proposed implementation actions to be undertaken by the Water Board. These actions are applicable to all source categories. Tables 12-16 describe proposed actions for responsible parties for reduction of pathogen loading from each major source category. These implementation actions will be described in greater detail in the final staff report that will accompany the Basin Plan Amendment for this TMDL. Details will be developed in close coordination with parties responsible for implementation actions and other interested stakeholders.

Table 11 Proposed Water Board Implementation Actions to Reduce Pathogen Loading
1. In coordination with responsible parties and interested third parties in the watershed, conduct monitoring program to measure progress toward, attainment of water quality objectives, meeting benchmarks, and compliance with TMDL implementation plan.
2. Assist in establishing funding mechanisms for implementation and monitoring.
3. Report to stakeholders on progress in meeting implementation of management measures and attainment of water quality objectives, including a discussion of options for regulatory action and follow-up, as needed.
4. Implement, as necessary, WDRs or waiver of WDRs related to pathogen reduction.

Table 12 Proposed Implementation Actions to Reduce Pathogen Loading from Septic Systems	
Implementing Party	**Action**
Sonoma County Permit and Resource Management Department	1. In cooperation with the Water Board and Sonoma Valley County Sanitation District, identify areas of greatest water quality concern from septic system failure based on proximity to impaired reaches, soil type, topography, and other factors.
	2. Submit a plan and implementation schedule to evaluate septic system performance for the watershed and to bring identified septic systems up to appropriate repair standards. Priority should be given to systems identified as posing water quality risks.
	3. Report progress on implementation of pathogen reduction measures.

Table 13 Proposed Implementation Actions to Reduce Pathogen Loading from Sanitary Sewer Systems	
Implementing Party	**Action**
Sonoma Valley County Sanitation District	1. In cooperation with the Water Board and Sonoma County Permit and Resource Management Department, identify areas of greatest water quality concern from collection system failure based on proximity to impaired reaches, soil type, topography, and other factors.
	2. Develop Sanitary Sewer Management Plan in accordance with Water Board/BACWA guidelines (see Section 9.4, pages 36-37). Plan should include provisions to identify and repair collection system failures. Priority should be given to areas identified as posing water quality risks.
	3. Report progress on implementation of pathogen reduction measures.

Table 14 Proposed Implementation Actions to Reduce Pathogen Loading from Municipal Runoff	
Implementing Party	**Action**
Sonoma County Water Agency, County of Sonoma	1. Implement stormwater management plan.
	2. Update/amend stormwater management plan to include specific measures to reduce pathogen loading.
	3. Report progress on implementation of pathogen reduction measures.

Table 15 Proposed Implementation Actions to Reduce Pathogen Loading from Cattle Grazing	
Implementing Party	**Action**
Owners of Cattle Grazing Operations	1. Participate in ongoing RCD/NRCS conservation programs.
	2. Implement management measures that reduce pathogen runoff.
	3. Where water quality impacts are identified, implement site-specific source control measures and conservation practices.
	4. Submit report of Waste Discharge or comply with conditions of WDRs waiver or discharge prohibition.

Table 16 Proposed Implementation Actions to Reduce Pathogen Loading from Dairies	
Implementing Party	**Action**
Dairy Facility Owners	1. Participate in Sonoma-Marin Animal Resource Committee. The Committee supports dairy operators in their efforts to solve waste control problems and locate technical and financial assistance. The committee serves as a vehicle through which the Water Board and DFG can disseminate information on water quality regulations and requirements.
	2. Participate in an annual training program that identifies water quality concerns and site-specific best management practices for reducing such water quality impacts (e.g., Dairy Quality Assurance Program Training).
	3. Ensure that facility is in full compliance with applicable Waste Discharge Requirements (WDRs) or waiver of WDRs.
	4. Where water quality impacts are identified, implement site-specific source control measures and conservation practices.

9.6 Evaluating Progress Towards Attaining Implementation Goals

It is important to monitor water quality progress, track TMDL implementation, and modify TMDLs and implementation plans as necessary, in order to:

- assess trends in water quality to ensure that improvement is being made;
- address any uncertainty in various aspects of TMDL development;
- oversee TMDL implementation to ensure that implementation measures are being carried out; and
- ensure that the TMDL remains effective, given changes that may occur in the watershed after TMDL development.

The primary measure of success for this TMDL is attainment or continuous progress toward attainment of the TMDL targets and load allocations. However, in evaluating successful implementation of this TMDL, attainment of trackable implementation actions will also be heavily relied upon. Therefore, we propose two types of monitoring for this TMDL: 1) water quality monitoring, and 2) monitoring of implementation of actions.

A formal water quality monitoring program for pathogen indicator bacteria will be developed by Water Board staff in coordination with stakeholders. Monitoring should begin as soon as possible, and should initially focus on previously identified hot spots and tributaries not assessed in previous work. Initial water quality monitoring objectives will be to:

- evaluate spatial and temporal water quality trends in the Creek and its tributaries
- further identify significant pathogen source areas
- collect sufficient data to prioritize implementation efforts and assess the effectiveness of implementation actions

9.7 Adaptive Implementation

Approximately every five years, the Water Board will review the Sonoma Creek Watershed Pathogens TMDL and evaluate new and relevant information from monitoring, special studies, and scientific literature. The reviews will be coordinated through the Water Board's continuing planning program and will provide opportunities for stakeholder participation. Any necessary modifications to the targets, allocations, or implementation plan will be incorporated into the Basin Plan. In evaluating necessary modifications, the Water Board will favor actions that reduce sediment and nutrient loads, pollutants for which the Sonoma Creek Watershed is also impaired. We are seeking input from stakeholders on the type of studies needed to further refine this TMDL and answer any outstanding questions. At a minimum, the following questions will be used to conduct the reviews.

- Are the Creek and the tributaries progressing toward TMDL targets as expected? If progress is unclear, how should monitoring efforts be modified to detect trends? If there has not been adequate progress, how might the implementation actions or allocations be modified?
- What are the pollutant loads for the various source categories (including naturally occurring background pathogen contributions and the contribution from open space lands), how have these loads changed over time, how do they vary seasonally, and how might source control measures be modified tofurther reduce loads?
- Is there new, reliable, and widely accepted scientific information that suggests modifications to targets, allocations, or implementation actions? If so, how should the TMDL be modified?

If after five years the Water Board determines that load and density reductions are being achieved as management measures are implemented, then the recommended appropriate course of action would be to continue management measure implementation and compliance oversight. If it is determined that all proposed control measures have been implemented, yet the TMDL is not achieved, further investigations will be made to determine whether: 1) the control measures are not effective; 2) the high levels of indicator bacteria are due to uncontrollable sources; or 3) the TMDL is unattainable.

10. GLOSSARY

Bacteria: Single-celled microorganisms that lack a cell nucleus and contain no chlorophyll. Bacteria of the coliform and enterococcus groups are considered the primary indicators of fecal contamination and are often used to assess water quality.

Beneficial uses: Designated uses of water, including, but are not limited to, domestic, municipal, agricultural, and industrial water supply; power generation; recreation; aesthetic enjoyment; navigation; preservation and enhancement of fish, wildlife, and other aquatic resources and preserves. (California Water Code [CWC] section 13050[f])

Best management practices (BMPs): Methods, measures, or practices selected by an agency to meet its nonpoint source control needs. BMPs include, but are not limited to, structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters.

Catchment area: The area draining into a lake, reservoir, or stream; contributing watershed.

Coliform bacteria: See total coliform bacteria.

Colony-forming unit (CFU): A single bacterial cell capable of reproducing and giving a positive test response in the laboratory. As used in this document, CFU is functionally synonymous with "bacteria count."

Discharge: Flow of surface water in a stream or canal or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to the discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.

Effluent: Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, and the like.

Enterococci: A subgroup of the fecal streptococci that includes S. faecalis and S. faecium. The enterococci are differentiated from other streptococci by their ability to grow in 6.5 percent sodium chloride, at pH 9.6, and at 10°C and 45°C. Enterococci are a valuable bacterial indicator for determining the extent of fecal contamination of recreational surface waters.

Escherichia coli: A subgroup of the fecal coliform bacteria. E. coli is part of the normal intestinal flora in humans and animals and is therefore, a direct indicator of fecal contamination in a waterbody. The O157 strain, sometimes transmitted in contaminated waterbodies, can cause serious infection, resulting in gastroenteritis. See also fecal coliform bacteria.

Fecal coliform bacteria: A subset of total coliform bacteria that are present in the intestines or feces of warm-blooded animals. They are often used as indicators of the sanitary quality of water. They are measured by running the standard total coliform test at an elevated temperature

(44.5°C). Fecal coliform constitute up to approximately 20 percent of total coliform in fecally-contaminated samples. See also total coliform bacteria.

Gastroenteritis: An inflammation of the stomach and the intestines.

Geometric mean: Mathematically defined as the n^{th} root of the product of n factors. Geometric mean can also be described as the antilog of the mean of the logs of a group of numbers—that is, calculate the logarithms of your original measured values, calculate the mean of the logarithms, and calculate the antilogarithm of the mean. Geometric mean is regarded as more meaningful for describing bacteria water quality data than the simpler arithmetic mean.

Indicator: Measurable quantity that can be used to evaluate the relationship between pollutant sources and their impact on water quality.

Indicator organism: Organism used to indicate the potential presence of other (usually pathogenic) organisms. Indicator organisms are typically associated with the other organisms, but are usually more easily sampled and measured.

Load allocation (LA): The portion of a receiving waterbody's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources.

Loading capacity (LC): The greatest amount of loading that a waterbody can receive without violating water quality standards. The LC equals the TMDL.

Margin of safety (MOS): A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody (CWA section 303[d][1][C]).

Most probable number (MPN): A assay procedure that yields a statistically estimated bacterial count for a sample. MPN is often used as the reporting unit for these assays, in which case it is functionally synonymous with "bacteria count."

National Pollutant Discharge Elimination System (NPDES): The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits for point sources, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.

Nonpoint source: Pollution sources that are diffused and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by stormwater runoff. Commonly used categories for nonpoint sources are agriculture, forestry, urban, mining, construction, land disposal, and saltwater intrusion.

Pathogen: A microorganism capable of causing disease.

Point source: Any discernible, confined, and discrete conveyance including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture or agricultural stormwater runoff (40 CFR 122.2).

Protozoa: Single-celled organisms that reproduce by fission and occur primarily in the aquatic environment. Waterborne pathogenic protozoans of primary concern include Giardia lamblia and Cryptosporidium, both of which affect the gastrointestinal tract.

Septic system: An on-site system designed to treat domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a system of tile lines or a pit for disposal of the liquid effluent. Sludge that remains after decomposition of the solids by bacteria in the tank must be pumped out periodically.

Stakeholder: Those parties likely to be affected by, or that can affect, the TMDL.

Total coliform bacteria: A particular group of bacteria, found in the feces of warm-blooded animals that are used as indicators of possible sewage pollution. They are characterized as aerobic or facultative anaerobic, gram-negative, non spore-forming, rod-shaded bacteria that ferment lactose with gas formation within 48 hours at 35° C. Note that the total coliform group also includes many common soil bacteria, which do not indicate fecal contamination. See also fecal coliform bacteria.

Total Maximum Daily Load (TMDL): The pollutant load that a waterbody can receive and still meet water quality standards. The TMDL is the sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, and a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standards.

Virus: Submicroscopic pathogen consisting of a nucleic acid core surrounded by a protein coat. Requires a host in which to replicate (reproduce).

Waste load Allocation (WLA): The portion of a receiving waterbody's loading capacity that is allocated to one of its existing or future point sources of pollution.

Wastewater treatment: Chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.

Water Quality Criteria: Elements of water quality standards expressed as constituent concentrations, levels, or a narrative statement, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use. In California, water quality criteria are referred to as water quality objectives (WQO).

Water Quality Objective (WQO): See water quality criteria.

Water Quality Standard (WQS): Provisions of state and federal law that consist of: 1) a designated use or uses for the waters of the United States; 2) water quality criteria for such waters to protect such uses; and 3) statements to prohibit degradation (antidegradation policy). Water quality standards are to protect public health or welfare, enhance the quality of the water, and serve the purpose of the Clean Water Act (40 CFR 131.3).

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

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